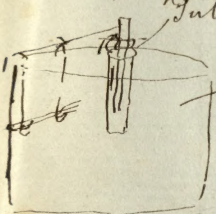
Electro Plating

Repose liquor Chloride of Silver
boil with Yellow Prussiate of Potash
in a clean tin or tinned Copper
vessel. Let it settle & pour off
the clear liquor

Glass Tube with Salt & water & holding a piece of Zinc



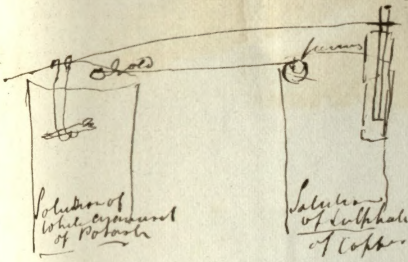
holds silvering liquor

when in a few minutes take out & rub with
Tripoli powder

ds must have the surface got off by rubbing with emery
powder & wash in solution of Potash. Quickly plunge
in bath
hen out of bath rub well with linen or calico
f it stands a fortnights rubbing use plate
more thickly

Two tumbler glasses

Gilding.



Matters wanted for both processes

Emery Paper

Cyanuret of Potash

Sulphate of Copper

Tripoli powder

Yellow Prussiate of Potash

Chloride of silver
or nitrate

Solution of nitrate of mercury — use with white metals
to coat over thing

ELECTROTYPE MANIPULATION:

96.3

PART I.

BEING

THE THEORY, AND PLAIN INSTRUCTIONS

IN THE ART OF

WORKING IN METALS,

BY PRECIPITATING THEM FROM THEIR SOLUTIONS,

THROUGH THE AGENCY OF

GALVANIC OR VOLTAIC ELECTRICITY.

BY

CHARLES V. WALKER,

HONORARY SECRETARY TO THE LONDON ELECTRICAL SOCIETY; EDITOR OF THE ELECTRICAL MAGAZINE, KÆMTZ'S METEOROLOGY, &c. &c.; SUPERINTENDENT OF ELECTRIC TELEGRAPHS TO THE SOUTH-EASTERN RAILWAY COMPANY.

Illustrated by Woodcuts.

TWENTY-SECOND EDITION.

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PREFACE

TO THE LATER EDITIONS.

The rapid sale of the earlier editions of this Work can only be traced to the great popularity of the subject on which it treats.

No branch of Experimental Philosophy has been more cultivated than Electrotype. Like all, it is replete with interest, whether examined in its theory or in its results,—unlike some, it leaves a trace of its footsteps,—a tangible evidence of its power. I allude not to its profitable applications in the hands of the artisan; furnishing, as they do, a full and forcible reply to the oft-proposed question "What is the *use* of Electricity?" For him these pages are not written;—his demands upon the art are of another nature, and are intimately connected with his own resources. I write for him who delights to devote a portion of his hours of relaxation to the study of those mysteries of nature, into which the eye of science has been able in a degree to penetrate. It may be safely said that in the length and breadth of England, the

proportion of such individuals is far greater than elsewhere; there is amongst us a national love of *home*, and of *home*-occupations; and when we do wander, we feel that we *are* wanderers; and can regard with pleasing anticipation the time which will return us to our *home*. Amongst home attractions is ever found a taste for the fine arts; this is seen even in the cottage, whose walls are adorned with "much that taste, untaught and unrestrained, surveys delighted;" the inmate of the humble tenement, "around whose walls are heroes, lovers, kings," surveys them with a satisfaction closely akin to that which animates the man of cultivated taste, as he views the perfect productions of a Raphael or a Correggio. This taste is abundantly gratified by the discovery of Electrotype; it enables each, who desires it, to furnish himself with durable copies of the finest productions of the chisel and the graver. He finds an inexhaustible field open before him;—and, if he devote his time to forming collections, he is animated at every step by the novelty and interest attached to each fresh acquisition. And not the least feature of interest allied to a collection thus formed, is the fact that every specimen is stamped with a double signature of "mine,"—"mine" it is by *possession*,—but especially it is "mine" by *production*.

When I consider how many copies of this treatise have, during the last year or two, been dispersed through all quarters of our land (and not *ours* only), I cannot but feel that it has been in some measure

instrumental in enabling very many to tread the same pleasing path that I have trodden. I trust my endeavours to pave the way have not been unsuccessful. On first venturing along the new-discovered road, I found many a stumbling-stone besetting my steps; and many a time have I had to survey before I could tell which track would lead to the desired end. These obstacles I have endeavoured to remove from the path of those who are interested in following the traces marked out; I have, too, watched with care the progress made by others; and have in each successive edition embodied as much fresh information as conveniently I could. To my more mature experience on the subject of mould-making; to the general principles on which the reduction of metals is based; and to the description of new arrangements of apparatus which, with revisions of many paragraphs, were given in the earlier editions, I have, in this, added all the improvements, up to the present time, that I could conveniently compress into these pages.

It was at first my intention* to have added observations on the deposition of other metals; this, however, was not found possible; there was so much to be said that could not be contained within the present pages, that I rather determined to unfold fully the principles and practice of the art in this treatise, and to prepare a Second Part, to be devoted to plating, gilding, etching, and all the several applications of the art, which,

* Preface to Fifth Edition.

for want of space, could not be introduced here. In Part II. will also be found the etching of Daguerréotype plates, and several modifications in Voltaic apparatus. In the FOURTH Edition of Part II., Electro-Printing is introduced; and the process of plating and etching are dwelt upon more fully.

CHARLES V. WALKER.

Westbourne, August, 1844.

PREFACE

TO THE EIGHTEENTH EDITION.

To the former Editions of this little Treatise, so many additions had been made, that the arrangement had become somewhat irregular. In preparing, therefore, the SIXTEENTH EDITION, I re-arranged the whole, re-wrote many parts, and added several interesting facts that recent investigations have brought to light. The same are continued in these later editions.*

C. V. W.

Tonbridge, June 1847.

* In the Twenty-first Edition, I have given a description of Gutta Percha and other moulds.—*Tonbridge,* June 1849.

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II.—Preparation of Moulds.

III.—Voltaic Apparatus to be used.

ELECTROTYPE MANIPULATION.

I. Introductory Observations.

1. The object of the present treatise is not so much to dwell upon the philosophical principles on which the art of electrotype is based, as it is to trace in a familiar manner the several processes in manipulation, and the precautions to be observed in order to escape failure. The instructions given are the results of a long course of experiment; and it will be the especial aim of the writer to dwell minutely upon those *little* points which so materially influence the success of the experiments. It will be the endeavour to avoid, as much as may be, the use of scientific phraseology; so that the amateur, for whose use this work is written, may find as few obstructions as possible besetting his path. In the course of forming a large collection of medals by the Electrotype process, and copying casts of large size, the author has, of necessity, been led to adopt such modes as convenience and economy dictated. These will be described in order, as the reader is led from the original medal to the perfect copy, ready for the cabinet.

2. Galvano-plastic, Electrotype, or Electro-metallurgy, is, as its several names indicate, intimately connected with Galvanic, or, as it is more fitly termed, Voltaic Electricity. In order, therefore, to convey correct notions on the subject, it will be requisite, before entering on it further, to give a brief outline of the principles of this science, and to trace their application to the art in question.

3. *Voltaic Electricity.*—Galvanism, or Voltaic Electricity, is the name given to that development of electricity discovered in the year 1790, by Professor Galvani, of Bologna, and subsequently more fully investigated by the labours of Volta, whose letter to Sir Joseph Banks, the then President of the Royal Society, announcing the discovery of the apparatus, named after him the Voltaic pile, is dated March 20th, 1800. It is obtained by certain arrangements of metals and liquids, of which the following may be taken as an illustration. If a piece of zinc and another of copper be attached one to each end of a wire, and the two be then placed in a vessel containing water, acidulated with sulphuric acid, it will constitute a simple *or single voltaic pair*, IN ACTION.

4. The action is dependent on the different chemical affinity of the liquid for the respective metals: it will dissolve the zinc rather than the copper: in other words, the water (which is well known to consist of the two gases, oxygen and hydrogen, chemically combined) is decomposed;—the *hydrogen* makes its escape at the surface of the *copper* plate in the form of gas; the oxygen *combines* with the zinc, and forms an *oxide of zinc;* this oxide unites with, and is dissolved in the sulphuric acid, forming *sulphate of zinc.* Actions analogous to this occur in *all* voltaic combinations. The exciting liquid has a *greater* affinity for one metal than for the other. The former is termed the *positive* metal; the latter the *negative.*

5. For most practical purposes, zinc is used as the positive metal,—either pure zinc, the zinc of commerce, or amalgamated zinc. (§ 46.) For the negative metal, copper is generally used; but a very convenient arrangement has been devised by Mr. Alfred Smee, (§ 65.) wherein platinized silver—that is, silver covered with minute particles of platinum—is employed. Another battery has been constructed by Professor Grove, of a very powerful nature, wherein plates of platinum are used. There is also a modification of this latter, con-

sisting of zinc and charcoal. Charcoal, or carbon, being the only other substance in nature—not metallic—which can be so employed.

6. I have here spoken (§ 4.) only of the *chemical* change which takes place; but in connection with this, and bearing a strict relation to it, is another phenomenon of the highest interest,—namely, the disturbance of electric equilibrium.

7. During the continuance of the chemical changes already described, (§ 4.) a transfer of electricity is quietly taking place between the two metals. The positive electricity (which, to avoid circumlocution, we will assume to be, as possibly it is, *the* electricity) passes *from the zinc through the liquid to the copper*, and then continues its course along the wire (§ 3.) by which the metals are joined, to the zinc again. If the wire is broken, the transfer of electricity is interrupted, and the chemical effects, so far as electricity is concerned,* cease; hydrogen is no longer evolved from the copper plate, and the zinc (if it is pure or amalgamated) ceases to be dissolved.

8. The fundamental principle, which cannot be too strongly enforced, is that the passage of the electricity *in the liquid* is *from* the zinc *to* the copper. If this simple fact is borne in mind, it will decide in every case the question which confuses so many—namely, —which is the positive, and which is the negative end of a battery? The positive is the end where the electricity *leaves* a battery; the negative where it *re-enters* it. The direction taken by the current being ascertained by the mere inspection of the situations of the two metals *in* a cell, the other points follow as a necessary consequence.

9. If, for instance, the wire connecting the two plates, (§ 3.) by which we have illustrated a single voltaic pair, were broken, and the circuit completed by interposing some apparatus between the broken ends,

* The *ordinary* chemical effects of the acid on the zinc continue, unless prevented by other means. (§ 46.)

an examination of the arrangement would at once show, that as the electricity passes *from* the zinc *to* the copper, it would leave the battery by the wire attached to the *copper* plate, and, having passed through the interposed apparatus, would return to the battery by the wire attached to the *zinc* plate; the copper, which is the *negative* metal, forming in this case the *positive end* of the battery; and the zinc, the *positive* metal, forming the *negative end.*

10. *Electrolysis.*—The *great* effects of voltaic electricity, those which have rendered it so attractive a science, depend on the various modes of combining a large or small number of these pairs of metals, and on the nature of the apparatus interposed between the wires connected with the respective ends of the arrangement. The power, which, from its effects, Dr. Faraday has termed the Electrolytic* power, is that which alone demands *our* attention, because on the right understanding of this depends the successful application of the art of Electrotype.

11. If a series of about ten of these voltaic pairs or batteries be arranged in the order of zinc, liquid, copper and the terminating wires, which for this purpose should be of platinum, be placed in a vessel of water containing sulphuric acid,† the water will be electrolyzed or decomposed by electricity; the hydrogen gas will be released at the wire connected with the negative end of the battery, and the oxygen at that connected with the positive. If these gases be collected separately in tubes placed over the platinum wires, the quantity of hydrogen will be double in bulk that of the oxygen.

12. If, into this acid liquid, some crystals of sulphate of copper be thrown, and the current be sent through, electrolysis will still take place,—the water will still be decomposed, but only *one* of the gases, the *oxygen*, will

* Vide Exp. Researches. Series 7, § 664.

† In this and all other similar instances the use of sulphuric acid is to increase the conducting power of the liquid;—to facilitate the passage of electricity through it. The modus operandi cannot be entered into here.

be obtained. The hydrogen, as it becomes released from the water, will take the place of the copper in the solution, and the *copper* will be liberated and become visible on the negative (§ 8.) wire. This experiment may be continued till all the copper is abstracted from the solution: the remaining liquid will be water, strongly acid.

13. A third modification of this experiment is by using for the positive wire, one of *copper*, instead of *platinum*. In this instance, too, the water is decomposed; but *neither* of the gases is visible. The hydrogen, as before, occupies the place of the copper in the solution, releasing the copper as in the last experiment; (§ 12.) the oxygen, instead of appearing at the positive wire, combines with the copper of which that wire is composed, forming an oxide of copper: this oxide unites with the sulphuric acid, and forms a sulphate of oxide of copper. In proportion as the solution is weakened by the release of copper at the *negative* wire, it is thus supplied with copper from the *positive*. If, in these experiments, a measuring instrument had been included in the circuit, it would be found that the first of the three presented the greatest resistance, and the last the least. For, in the last case, the chemical forces were made to conspire with the electric current.

14. It will be observed, in these illustrations of electrolysis, that the metals are released at the *negative* plate. One part of the science of Electrotype,—a science discovered in England by Mr. Jordan and Mr. Spencer, and on the continent by Professor Jacobi, consists in preparing for a negative plate models or moulds (§ 20 &c.) of objects to be copied; and in so arranging the battery, or apparatus which generates the voltaic current, (§ 43 &c.) as to release the metals in a compact and solid form upon these models.

15. On these two points many precautions are to be observed; but a faithful compliance with the directions to be given will enable the least skilled to obtain metallic copies of the most beautiful works of art, by merely exercising ordinary care and a little patience.

16. *Constant Voltaic Battery.*—Before closing these preliminary observations, it will be requisite to give a brief description of the Constant Battery. The voltaic pair immersed in a cell of acid water (§ 3.) is liable to some objections. First: The bubbles of hydrogen released on a common copper plate partially adhere, and of necessity prevent portions of this plate from being in actual contact with the liquid; and hence its power is less than it might be. The dissolved zinc, too, is partially released and deposited on the copper or negative plate, according to the laws already illustrated (§ 13.); hence arise counter-currents, which weaken the force.

17. The late Professor Daniell, by the invention of his constant battery, has enabled us to overcome in a very great measure these difficulties,—to remove these objections. The deposition of the zinc is obviated by using two liquids, separated by a porous partition, or, as it is called, a diaphragm, of animal membrane, paper, (§ 44.) earthenware, plaster of Paris, wood,* &c. (§ 48.) The liquid contiguous to the zinc is, as before, (§ 11.) acidulated water; that near the copper is a solution of sulphate of copper.† By this arrangement, it will be seen, from what has been already stated, (§ 13.) that *copper* will be released, in place of *hydrogen* on the copper,—the negative plate.

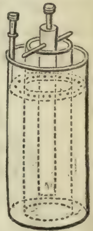
18. The *continuous* action of this battery is preserved by *amalgamating* (§ 46.) the zinc, and supplying the cupreous solution with crystals of sulphate of copper. (§ 50.) The former prevents the acid acting *chemically* on the zinc (§ 7.) and destroying it uselessly: the latter keeps up the strength of the solution, which is being constantly exhausted by the reduction of the copper. Fresh acid water is occasionally added.

This instrument is termed a *constant* battery, from its power of continuing a generally steady action for a lengthened period of time. It has been constructed in

* Lime-tree or some other porous wood, boiled for an hour, at least, in water containing a little sulphuric acid.—*Jacobi.*

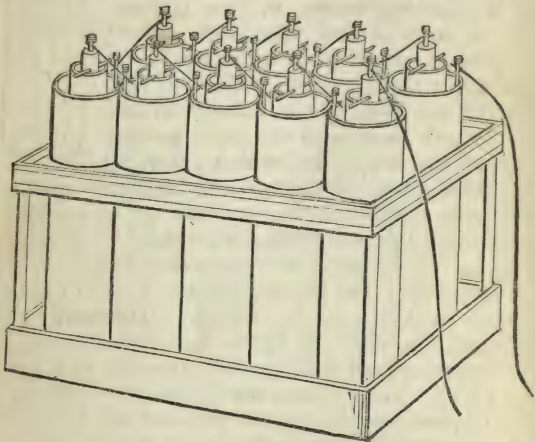
† This is more properly termed sulphate of *oxide of copper*.

various ways, being modified according to the taste of individuals, or to the use to which it is to be applied. But whatever *form* may be given to it, it is still the constant battery, invented by Professor Daniell, to whom alone the credit is due for devising so valuable an arrangement. The annexed woodcut represents a cell of a Daniell's battery. The cell, being of copper, itself forms the negative metal. A rod of amalgamated (§ 46.) zinc is placed, as shown in the figure, within a tube of porous earthenware. Attached to each metal is a binding screw, to form connections. A cell of this description is put into action by placing its several parts as shown in the figure; filling the porous tube containing the zinc with a mixture of one part sulphuric acid, and ten parts water; and filling the copper cell with a saturated solution of sulphate of copper.—By *saturated* is meant a solution containing as much of the salt of copper as the water will take up. This is prepared most readily by pouring boiling water on a superabundance of crystals of sulphate, and stirring them; to this solution one-tenth acid should be added. The perforated metal shelf, shown in the figure, is to support a supply of crystals to recruit the exhausted strength of the battery. (§ 50.) The crystals are placed thus *high up* in the liquid, because the upper portions are exhausted *first;* the specific gravity keeps the strong parts of the solution below.



19. *Note on Voltaic Batteries.*—While on the subject of voltaic pairs, it would be as well to pen a few lines on the powers of the battery, which are not directly connected with the art of Electrotype.—If a cell of the constant battery be charged as directed above, and a piece of fine platinum wire be stretched from the screw attached to the zinc, to that attached to the copper, it will attain a red or a white heat. This is termed the "heating power" of a battery. The larger the cell, the greater thickness of wire will be heated. If *too thin* a wire

be used, the passage of the electricity will be so much retarded as to produce no visible indications of heat. The *length* of wire that can be heated depends on the cooling power of the contiguous *air*; "a current that will heat one inch of platinum, will heat a hundred inches."* The law which regulates the comparative length of wires heated by different combinations of the batteries appears to be this: If one such cell as that described, heats x inches, and another cell y inches, the two arranged in series will heat $x+y$ inches.†



If a series of cells be arranged, as in the annexed figure, by uniting the copper of one to the zinc of the other, and points of charcoal be attached to the terminating wires, upon bringing these points into contact and then separating them, the well known phenomenon of the voltaic flame is produced. The *length* of this flame depends on the number of cells used; the size or *thickness*, (if we may use the term,) on the size of the cells. The flame from a hundred cells is very brilliant; in some experiments at which I assisted,

* Faraday's Researches. Thirteenth Series. § 1631.
† Transactions Electrical Society, p. 63. § 36.

made with a series of upwards of three hundred, it was needful to screen the eyes with a black silk veil.* Few things resist the intense heat of this flame; the metals are speedily dissipated in fumes; platinum and gold are melted and vaporized.—The arrangement of cells in series will produce a shock on the human frame, intense in proportion to the *number* in the series. Thirty will produce the effect: three hundred will produce more than a man with ordinary nerves could endure. The electrolytic power of the battery is only manifested on bodies in solution, or on bodies made liquid by heat; and these several bodies are acted upon with various degrees of facility. Solution of iodide of potassium is most easily decomposed. A battery consisting of a mere *wire* of zinc and one of copper, will decompose this solution, even by means of *platinum* wires. Water is more difficult of decomposition. Ten cells of a Daniell's battery are a convenient number to effect the decomposition of water. A series of twenty will release very little more gas than one of ten; but *two* series of ten placed *side by side* will do twice the work of *one* series. By an arrangement of this kind it is that the maximum of decomposing power is obtained from a given number of cells. Chlorides of lead or silver, or chlorate of potassa, &c., &c., do not conduct the current in their solid state, and therefore resist decomposition; but, when made fluid by heat, they obey the same general law as do solutions. When sulphuret of antimony is fused by a powerful voltaic flame, the heat of the same current will keep it fused, while the current itself decomposes it.—One or two thousand cells containing pairs of plates (copper and zinc) connected in series, and charged with water, produce effects closely analogous to those obtained by the common electric machine. This is termed a water-báttery.—There is a beautiful regularity in the action of batteries, that cannot fail to interest the most casual observer: it is a regu-

* Since the above lines were written, active exertions have been made to apply this light to ordinary purposes.—*June* 1849.

larity to which the attention of the electrotypist should be especially directed. When a number of cells are connected in series according to the plan represented in the woodcut, precisely the same amount of action occurs in each. If in one an ounce of zinc is consumed, so also is it in every other; and in each, too, a weight of copper is deposited on the surface equivalent to the ounce of zinc. And, if the terminating wires of this apparatus be placed to produce the decomposition of a solution, precisely the same amount of the solution will be decomposed, as is equivalent to the quantity of zinc consumed or copper released in each cell.—If water be the subject of experiment, the same arrangement of battery will release more or less gas, according to the degree of conductibility given to the water by means of sulphuric acid; the less conductible it is, the greater resistance it offers to the passage of the battery current, the less gas is released, and the less zinc is consumed: as the conductibility increases, the rate of decomposition is higher, and the energy of the action in each battery cell is greater. There is a harmony in all this consistent with what we have hitherto learned of the laws of nature. The knowledge of this law is no small addition to the science of electricity: and it must not be forgotten, that the development of this beautiful system of things is due to an *English* philosopher, Faraday, whose perseverance in research has been crowned with unusual success. Without dilating longer on these general features of the science, I shall pursue the object at present in view, and endeavour, with as much brevity as is consistent, to explain the nature of the Electrotype art, with so much of its theory as, joined with what has been already said, may guide the experimenter safely through each process.

II.—Preparation of Moulds.

20. I can very reasonably conclude that the amateur will commence his experiments on the smaller works of art; and, as a knowledge of the mode of manipulation

to copy these will, with a little practical experience, easily pave the way towards accomplishing greater things, I shall dwell principally on the art of copying medals, medallions, seals, &c., taking the reader with me through the entire process.

21. There are many materials fitted for forming moulds; of these—*fusible metal, wax, stearine, gutta percha,* and a composition whose base is *spermaceti,* are mostly used. The first is applicable to all medals of ordinary size,—the others to plaster medallions and larger medals.

22. *Fusible Metal.*—This is an alloy, consisting of bismuth, tin, and lead; it melts at a low temperature, —a few degrees below that of boiling water: and has been used as a philosophical toy, in the form of spoons, which melt in hot tea. For the latter purpose, it generally contains a small portion of mercury. Since the discovery of Electrotype, it has been prepared for that process without mercury.

23. The proportion of the different ingredients in a pound of this alloy is:—

	oz.
Bismuth	8
Tin	3
Lead	5
	16 = 1 lb.

These should be melted together in a *clean* iron ladle, taking care to keep it on the fire no longer than is necessary to produce the complete liquefaction of the several ingredients. When melted, pour the metal on a stone or marble slab in drops. Then, after having *rubbed the ladle clean* with coarse paper, return the pieces of metal, re-melt them, and pour them out in drops as before. A third melting will ensure the ingredients being well mixed. To retain the metal in a fit condition for use, the ladle must be frequently rubbed clean; and must always be removed from the fire *as soon* as its contents are melted. The former

ensures a bright surface to the mould ; the latter preserves the alloy from waste by oxidation.

24. *To make a Mould in Fusible Metal.*—Melt some in the iron ladle, and pour it on a slab ; then, from the height of two or three inches, drop on it the medal to be copied, taking care that the medal is COLD. In a few *seconds* the metal will be solid, and may be placed to cool ; when it is cold, either with or without a few slight taps, the two will separate ; and, if proper care has been taken, an *exceedingly sharp* mould will be obtained. The novice must not, however, be disheartened if his first attempts to obtain good moulds fail : for there are so many little accidents which may happen, that the most practised manipulator may have to repeat his attempts. A slight shake of the hand may drop the medal irregularly ;—too much sunk, for instance, on one side. A film of oxide may rest on a portion of the surface of the melted metal, and render the corresponding portion of the cast *dull.* Dull looking moulds must always be rejected, for so minutely correct is the process of Electrotype, that the dulness of the mould will be transferred to *every* copy made from it. Even if an original medal be incautiously handled, the slight trace of a finger-mark will be transferred to the mould ; and thence to the Electrotype copies.

25. The fusible metal will not always pour into a *round* mass, to receive the medal : unless the slab is perfectly level, it runs into a stream. This is a great inconvenience, but may be remedied by having a shallow cavity (saucer fashion) made in the marble ; or by using any article of *earthenware*, which the kitchen or the laboratory may furnish, suited to the purpose. I have been in the habit of using the brown stoneware saucers, in which blacking is sold ; and in them have produced some of the best moulds. They are to be inverted, and the metal is to be poured on them.

26. *Clichée Moulds.*—The following is the mode

adopted on the continent for obtaining the beautiful casts of the French medals, which are so much admired. These casts are in a fusible alloy, containing *antimony*, as well as the other ingredients. (§ 23.) The composition is :—*

Bismuth	8 parts
Tin	4
Lead	5
Antimony	1

The metals should be repeatedly melted and poured into drops, until they are well mixed.

27. A block of wood is then turned into a shape similar to that of a button-die, into one end of which is worked a cavity, the size of the medal to be copied, and *not quite so deep* as its thickness; in this cavity the medal is placed; should it not fit tightly, a circle of paper is pressed in with it: the medal, being thus firmly mounted, is to be copied in the following manner :—

28. A sheet of smooth cartridge paper is fixed, by drawing pins or otherwise, withinside a box having sides about four inches high, which slope inwards in order to prevent the metal from being scattered away; the part to be used is very slightly oiled with a single drop of oil; on this is poured some of the prepared alloy, which should be removed from the fire as soon as melted. (§ 23.) The metal is then stirred together with cards until it assumes a pasty appearance, and is on the eve of crystallizing; if, at this stage, the surface should appear defaced with dross, one of the cards must be passed over it lightly and speedily; should no dross appear, this part of the process may be omitted. The die containing the medal, must then be held firmly in the right hand, and be struck gently and steadily upon the solidifying metal. Should an assistant be at hand to aid in this, it will be as well; for sometimes, during the brief interim, while the card is being exchanged for the die, the exact moment is lost,

* Vide Proceed. Elec. Soc. part ii. p. 90, Aug. 17, 1841.

and the mould is imperfect. When one stirs the metal, and the other is prepared with the die, the operation can be timed to a nicety. When an assistant is not at hand, the die should be placed within reach of the right hand, with the medal downwards. A little ingenuity will readily suggest the construction of a press, by which this part of the process could be accomplished. Large medals are moulded without the die, by dropping them in a sidelong direction upon the solidifying metal.

29. The beauty and perfection of moulds thus obtained will amply repay the trouble of producing them,—though I am not quite justified in using the word "trouble:"—for by this mode, with ordinary care, two out of every three casts are perfect; besides, therefore, the economy of time, the saving in the reduced oxydization of metal is thus of no inconsiderable importance.

30. This method of producing moulds is not confined to obtaining them from medals, which melt at a *high* temperature; they may be obtained from the common *soft*, *white* metal, with little danger of damaging the original. They may also be obtained from the metallic casts, which are extant, of the French medals of Andrieu, &c. Moreover, if the fusible mould itself be cut round and fitted into the block in place of the medal, it may be employed as a die; and casts, *perfect* casts, equal in respect to fidelity, and similar to the original medal, may be obtained. This is, in fact, the method by which the French medallions, some of which are in most cabinets, are produced.

31. Having obtained a mould, varnish the back and edge,—and also a portion of the front, when the surface of the mould around the impression is larger than necessary. The best varnish is good sealing-wax dissolved in spirit of wine; but for immersion in the cyanide solutions to be described hereafter (§. 95), wax or, which is better, pitch must be used. It

will now be ready for use, and is to be attached to a copper wire. The end of this wire must be *quite clean;* the wire is placed across the flame of the candle, with the clean end beyond the flame; it is to be touched with a piece of rosin, and pressed on the edge of the mould. The mould will instantly melt to receive it, and in a few seconds it will be cold and firmly fixed. The moulds should be wrapped in paper, if they are not intended for immediate use.

32. *Wax Moulds.*—The manipulation with this material is very simple. The wax employed is the common white wax, or the ends of wax candles. It is to be melted in an earthen pipkin or a small jug, and kept by the fire-side a few minutes after it is well melted. The medal to be copied should be made warm,—the warmer the better (the object being to prevent the sudden chill of the wax when poured on). It is to be surrounded with a rim, composed of a ribbon of paste-board. The end of this may conveniently be secured by a small *cleft* stick. The surface of the medal should be *very* slightly covered with olive oil. The hot wax is then poured on. It may require five or six hours to become sufficiently cold for removal; and great care must be taken to allow the cooling process to be gradual; for, without this precaution, the moulds, especially when of large objects, are apt to split. There will be at times a difficulty in removing wax moulds from medals with elaborate work. This may be obviated by a little care: the medal should be very slightly warmed by the heat of a candle, so as to cause a trifling expansion of the metal; and the wax is then to be drawn cautiously, and at right angles, from the surface of the medal. This applies to other composition moulds.

33. *Stearine Moulds*, &c.—From a few practical inconveniences attendant on the use of wax, I have at times preferred *stearine*, and consider it on the whole very useful, especially in copying works in metal; but recent experience has taught me that a still better

material, is a composition consisting of 8 oz. of spermaceti to 1¾ oz. each of wax and mutton suet. The Rev. F. Lockey recommends a mixture of wax, stearine, and *black-lead*. On this hint, I have added black-lead to some of my compositions, and with advantage. Since writing this paragraph, I have examined some moulds made with wax and a little of what is termed *Flake-white*, and never saw any to equal them,—nay, not even the metal moulds.

34. That such compositions will produce minutely correct copies of plaster casts renders them invaluable to the electrotypist, who employs his scientific resources towards the formation of a collection of works of art. For he is thus enabled to transfer impressions from the frail and perishable *plaster* to the durable *copper;* and to transfer them with all their beauty and all their perfection. They who have obtained but a casual insight into the treasures transferred to this delicate, but brittle material, have seen enough to assure them that there is an ample store to suit every taste and every temper. For a few pence, specimens of first-rate execution may be obtained from any of the plaster shops in London;—they are often to be met with in the hands of the Italian boys, who frequent the streets. Care should be taken that the specimens selected are free from defect. A few weeks' experience among medals will be of more avail, in guiding the judgment, than pages of written instructions.

35. *To copy Plaster Casts.*—Pour some *boiling* water into a plate; stand the cast *face upwards* in this water: the water must not be deep enough to reach the *face* of the cast. In a few minutes, the cast will be filled with water.* Then, without loss of time, wrap round it a ribbon of pasteboard as before, (§. 32.) and *immediately* pour in the melted composition. After it becomes solid, let it remain for two or three hours,

* The *small* delicate casts, which are slightly *tinted*, are best copied by first moistening their surfaces with olive oil, and then pouring on the wax.

and the mould may *generally* be lifted off from the plaster, without further trouble.

36. This, however, is not always the case, for if the water, with which the plaster is soaked be too cool, or if the cast be not perfectly saturated, the wax will ad here; and even with every care, this will at times be found to occur, on account of imperfections in the structure of the cast. Unless the latter has been cast from good plaster very well mixed and stirred, it will be of a rotten texture and will readily break off in fragments after it has once been wetted; and these fragments will adhere to the mould. Having thus destroyed the cast, it is an object of some importance to preserve the mould by removing the fragments without affecting the wax surface. This is readily done by gently touching each spot of plaster with a wire dipped in sulphuric acid; and then leaving the cast exposed to the air for ten or twelve hours. The acid will gradually absorb moisture from the atmosphere, and their mutual action will so disintegrate the plaster, that it may be entirely washed away with a camel's hair brush and cold water. This simple process has been the means of effectually restoring to me many moulds, which otherwise would have been doomed to the same fate as the casts from which they had abstracted plaster.

37. *To render Non-Metallic Moulds Conductible.*—But wax and such like bodies are non-conductors; and as such will not be of any service to convey the voltaic current. In order to render their surface condutceous, many plans have been devised. There is one which combines the three advantages of simplicity, certainty, and economy. It is to cover the surface with black-lead; the application of this substance was recommended by Mr. Murray; it was also employed by Prof. Jacobi, and its management is described in his "GALVANO-PLASTIC."

38. This article is known in commerce under the several names of plumbago, graphite, and black-lead. The latter might naturally enough induce those unac-

quainted with the subject, to conclude that *lead* held a prominent place in its composition. This, however, is not the case; it contains no lead at all; it consists of carbon and iron;* the principal portion being *carbon*. This substance has been already mentioned; (§ 5.) it is a very good conductor. Plumbago is largely used in the arts: the finer sorts for drawing-pencils, the inferior in domestic economy, for polishing iron-work. It does not seem that the difference of quality in this substance depends entirely upon the quantity of carbon it contains. The common qualities, such as are used for polishing stoves, are very good conductors; and, if tolerably *pure*, will answer our purpose as well as the best among the finer specimens. Unfortunately, however, the common kinds of black-lead are largely adulterated: among the substances used for adulteration, are plaster of Paris and charcoal. The philosophical instrument makers, who sell the apparatus for Electrotype experiments, generally keep plumbago in a fit condition for applying to wax moulds.

39. It may be applied DRY. Having breathed slightly on the mould, dip a soft brush into the plumbago, and rub it briskly over the surface: continue this, breathing on it occasionally, till the whole presents the well-known black-lead polish. Be very careful to rub the brush into every spot. The best kind of brush is a strong and fine camel's hair pencil. With care this operation will not affect the sharpness of the mould in the slightest perceptible degree. When the mould seems to be covered, if, upon breathing on it, any parts appear *whitish*, repeat the operation.—In some cases the black lead may be applied wet, and afterwards polished.—Messrs. Elkingtons used the following mixture, instead of mere plumbago: Zinc is melted in an iron ladle until near the point of burning, when a few pieces of iron are dropped into it. When cold, the mixture is very friable. They reduce it to a fine powder, and mix it with plumbago, which they apply

* Its chemical name is carburet of iron.

as before.—A clean wire slightly warmed, and pressed against the back of the mould, will become firmly imbedded in it. Then rub the wire and the wax about it with the plumbago brush, in order to complete the connection between the two. It is advisable to remove any plumbago which may have been spread on the edges of the mould, by scraping them with a knife. The mould is then ready for use, if *small;* but if *large*, the " guiding wires " recommended by Mr. Phillips, of St. Austell, may be occasionally added with advantage. One or more thin wires are twisted round the main wire, and their ends are allowed to rest against different parts of the mould, especially in the recesses of deep relief; and thus the copper may be led to deposit over all parts of the surface in a short time. When this is effected, the guiding wires are carefully removed.—Sealing-wax impressions are coated with plumbago. To cause it to adhere, moisten the seal *slightly* with spirit of wine, or expose it to the vapour of ether. For delicate objects, as flowers, insects, &c., which cannot withstand the action of brushing, other modes must be adopted.—One method is to dip the article in a weak solution of nitrate of silver, and while moist to expose it to the vapour of phosphorus, under a tumbler or bell-glass. The vapour is procured by placing a watch glass, containing phosphorus dissolved in alcohol, in a saucer of hot sand. By this operation, the metal silver is reduced from its nitrate; and thus the surface of the article is made conducteous. This process has in some cases, been adopted conjointly with the plumbago; on large objects, the black lead surface has been painted, first with nitrate of silver in solution, and then with the solution of phosphorus. The silver is sometimes reduced by the action of light; the same object has been also accomplished by allowing a jet of sulphurous acid gas to impinge on the surface moist with the nitrate.—The best preparation of phosphorus, however, is its solution in bisulphuret of carbon. This highly inflammable and very volatile compound

greedily dissolves phosphorus; but about $\frac{1}{20}$th part of phosphorus will be found sufficient. The object is merely dipped in this; and, after a few seconds, is immersed for a short time in a weak solution of nitrate of silver, and then allowed to dry in the light. The greatest care must be exercised in these operations; for the articles themselves will often inflame spontaneously, if allowed to remain, after having been in the phosphorus solution;—it must not be dropped about; for, although apparently innocent at the moment, it may afterwards ignite, and cause very serious accidents. It must not be allowed to insinuate itself beneath the nails of the hand. A preparation of wax, containing a little of this solution, is sometimes used; it is melted, and the objects, when dipped in, need no further preparation.

40. *Plaster of Paris Moulds.*—Another mode of making moulds is with fine plaster. They are to be saturated with wax or tallow, by standing them in a shallow vessel containing these substances in a melted state, or they may have their surfaces covered with fine varnish, if the work will permit it; or they may be heated with hot boiled oil, containing a little bees' wax; and when cold they are to be coated with plumbago. (§ 34.) The best fine plaster should always be used; it should be *fresh:* if kept any time, it must be preserved from the air in jars or otherwise. In mixing, water is first poured into a lipped bason; the plaster is gradually dropped in, and the supernatant water poured away: the water which remains with the plaster is the proper proportion to be stirred with it: when well mixed, let a small quantity be brushed into all the work of the medal with a camel's-hair pencil; this removes air bubbles: then pour on the plaster to the thickness required. If the objects to be copied be lightly oiled first, little difficulty will be experienced in removing the plaster-mould when "set."—Fusible moulds will, with proper care, produce successively as many Electrotype copies as the operator pleases. Wax or composition moulds are most

commonly damaged more or less, in removing the deposit.

41. When the object is undercut, the plaster mould may be made in pieces; and when put together in a mother-piece, the joinings must be modelled up. I have adopted this plan in some Electrotypes of Thorwalsden's "Triumph of Alexander;" in others, I have made the mould on the plaster cast, and have then broken the latter carefully away, so as to leave me a mould in a single piece. In either case, the mould requires to be broken away from the Electrotype.

42. *Elastic Moulds.*—Three parts of treacle are added to twelve parts of glue that has been carefully melted, and the whole is well incorporated. Metal and other objects, which would not "deliver" on ordinary moulds, on account of their high relief, may be readily moulded by this preparation, which will stretch during the removal of the mould, and will readily return to its original form.

Another Plan.—To a pound of gelatine or of the best fish glue, add three quarters of a pint of water and half-an-ounce of bees-wax, and dissolve it over the fire in the way of ordinary glue: use it when at about the consistency of syrup. The plaster-cast must be oiled before the mould is taken from it. This is Mr. Mitchell's plan, and may be at times useful.

Gutta Percha Moulds.—This material will be found very valuable. In making moulds from *metal* originals, a piece is to be cut from a sheet of gutta percha about the size required; and, after being softened in water at the temperature of 150° or 160°, is to be pressed by screw-pressure or otherwise into the medal. Plaster originals may be copied most accurately, without undergoing any previous preparation, by the employment of gutta percha macerated with a little coal naphtha. This preparation is made very plastic by warm water, and does not require much pressure to produce most faithful copies, and without damaging the cast. It is more convenient to purchase it prepared than to make it. It may be obtained of the Publishers of this book.

III.—Voltaic Apparatus to be used.

43. The moulds thus prepared are fitted to fill the place of the negative or copper plate, in the generating* cell of a simple constant voltaic pair; (§ 17.) or of the negative plate in a decomposition† cell. In either case they occupy the place where hydrogen is evolved, if the liquid is acid water; (§ 4, 11.) and where copper is reduced, if this acid water contains sulphate of copper. (§ 12, 13, 18.)

44. For the simplest mode of obtaining an Electrotype medal, the reader is referred to the description given (§ 3.) of a single voltaic pair. Instead of using the copper-plate as there described, attach (§ 31.) to the end of the wire one of the fusible moulds. (§ 24.) Bend the wire into the shape of the letter ∩, so that the mould shall face the zinc:—wrap the zinc in a piece of brown paper; pour within the paper some salt and water, or some water very slightly acidulated with sulphuric acid; and immerse the whole into a vessel containing a saturated (§ 18.) solution of sulphate of copper, having a little acid in it.

45. This apparatus will represent a single cell of a constant battery; (§ 17.) not constructed on the best principles, it is true, but sufficiently so for an introductory experiment. The copper of the solution will be released on the fusible mould: (§ 17.) after a few minutes' immersion the mould will be covered with a very brilliant coating of pure metallic copper;—after thirty hours, or less, with proper arrangements, (§ 58) this coating will be thick enough to remove:—when removed, it will present a perfect resemblance to the original medal.

46. *Amalgamation.*—To complete, however, the character of this constant voltaic pair, the zinc must be amalgamated; for besides the *electric* action into which

* This term is applied to that cell containing the single voltaic pair of zinc and copper, or other metal. (§ 3.)

† This term is applied to the second cell, into which the terminating wires (§ 11, 12, 13.) are brought.

common zinc may enter, the acid acts on it *chemically:* —whether the former action be going on or not, the latter will not cease so long as there is any zinc to be acted upon, or any acid to act upon it. This partly arises from the quantity of foreign matter contained in the zinc of commerce:—this matter, which is mostly metallic, forms, with the particles of zinc, very many small voltaic pairs, all acting independently of the negative plate, (§ 3, 17.) and at the expense of the zinc and acid. *Pure* zinc, which may be obtained where Electrotype apparatus is sold, is not to this extent destroyed.

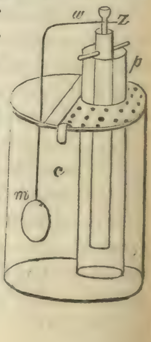
47. The process of amalgamation is this:—place some mercury in a saucer or plate; pour on it some water and sulphuric acid; brush the liquid and mercury over the surface of the zinc, till the whole is covered with a *bright* coat of mercury.

48. *Diaphragms.*—But the paper diaphragm above mentioned is very inconvenient in experiments of any duration; it seldom, perhaps never, prevents the partial mixing of the liquids it is designed to separate; and its use is always attended with a great waste of the sulphate of copper, the metal from which is released in great abundance, and deposited within the folds of the paper. The same may be said, though in a less degree, of animal membrane. Either will do very well for solitary experiments; but both are inconvenient, when the experiments are continued. Something more substantial and more durable is requisite. For this purpose porous tubes have been constructed of the material used for butter coolers: others have been made of pipe-clay. These are very capital diaphragms.

49. Very good diaphragms are easily made from plaster of Paris; and for this purpose the coarse plaster used by builders is best, care being taken to have it as *new and fresh* as possible: it is mixed with water in the usual way, (§ 40.) and is poured into a mould of the following construction:—A core is turned out of hard wood, nearly cylindrical, but a little smaller

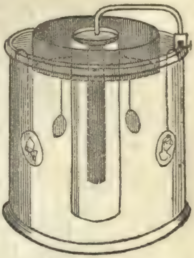
at one end, in order that it may draw out of the diaphragm when made; the thicker end has a shoulder rising a quarter of an inch or more beyond the surface of the core, according to the thickness required to be given. This, as well as the length and diameter of the core, will depend on the kind of diaphragm required. A thin sheet of tin or copper is now tied round the shoulder; and plaster being poured between the core and the envelope, a diaphragm is readily made. These diaphragms are very durable; and will be found a great acquisition to those who, from local circumstances, may not be able to obtain other kinds of porous ware. They are as good as *all* other diaphragms; better than a very large proportion; more economical than any.

50. If, in the introductory experiment already described, the amalgamated zinc and these diaphragms be employed, a constant battery is obtained, with all its parts complete. And if, in addition, a bag of crystals of sulphate of copper be hung in the blue solution, in order to recruit its strength, which is exhausted in proportion to the copper released; and the acid water around the zinc be occasionally renewed; the action may be continued for days or even weeks. And by removing the mould as soon as a sufficient thickness of copper is obtained, and supplying its place by another, three or four medals may be copied in a week.



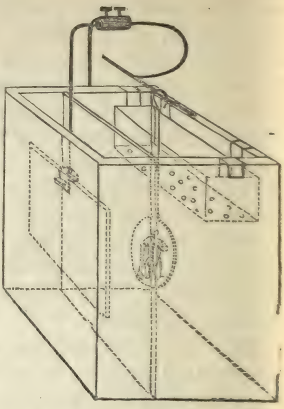
51. *Single-cell Apparatus.*—The annexed woodcut represents the single-cell apparatus in its complete form. Z is a rod of amalgamated zinc, *m* the mould, *w* the wire joining them, *c* the copper solution, *p* a tube of porous earthenware, containing a solution of acid and water. To put this in action, pour in the copper solution, fill the tube with the acid water, and place it as shown in the figure. *Last* (§ 75.) of all put

in the bent wire, having the zinc at one end and the mould at the other. Another form of this apparatus is here given. The zinc is connected by a wire and binding screws with a metal rim; and on the latter can be hung several moulds, as in the drawing. Things are much more likely to go on well when several moulds, as thus, are operated on, than when only one is introduced. The reason will be manifest hereafter.



52. The following precautions must be observed in using this apparatus.—The copper solution must be kept saturated, or nearly so;—this is effected by keeping the shelf well furnished with crystals. The mould must not be too small in proportion to the size of the zinc. The concentrated part of the solution must not be allowed to remain at the bottom. In the latter case, the copy will be irregular in thickness,—in the former, the metal may be a compact brittle mass; or may be deposited in a dull red, a violet, or a black powder. The nature of these several depositions will be elsewhere alluded to; (§ 62, &c.) so will also the relative proportions of the zinc, &c. (§ 78.)

53. *Single Cell without Acid or Mercury.*—The tyro must not imagine from the above descriptions that *acid* and *mercury* are the *sine quâ non* of success; because either of the above apparatus would be effective, though in a feebler degree, by charging the porous tube with a solution of sal-ammoniac, or even with one of common salt; and using zinc in its ordinary state; and employing a neutral solution of sulphate of copper. Sal-ammoniac, or hydro-chlorate of ammonia, consists of ammonia and muriatic acid. Its electro-chemical analysis is too complex to need a place here. Table salt, or chloride of sodium, consists



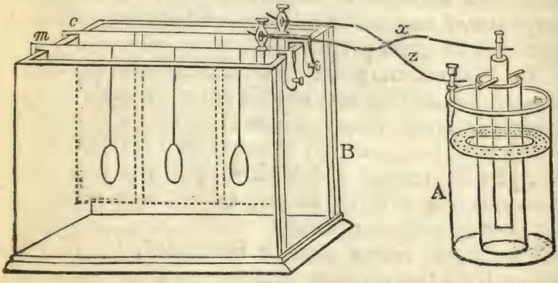
of the gas, chlorine, and the metal, sodium: its action is, that the chlorine combines with the zinc, and forms the very soluble chloride of zinc; and the sodium combines with the oxygen, that would be nascent at the diaphragm, and forms soda. This arrangement is not so powerful as the other, because the sum of the favourable, minus the unfavourable, affinities is less in the one case than in the other.

54. A single cell apparatus may consist of a wooden box, as shown above (§ 53.) well varnished in the interior, and divided into two unequal cells by a partition of porous wood. The wood is prepared as described above. (§ 17.) The larger cell is filled with a saturated solution of sulphate of copper, the smaller with a half-saturated solution of muriate of ammonia, or one of common salt. In the former is a shelf for containing a supply of crystals.

55. I do not recommend the use of the single cell arrangement, except for small objects; I do not adopt it on the large scale. Seals are electrotyped by the simplest form of the single cell: a warm wire is pressed into the edge of the seal, which is then covered with plumbago; the other end of the wire is twisted to a little piece of zinc, or even an iron nail, and the wire is bent ∩ fashion: a little diaphragm of card sewed up, having the joinings secured with wax, is filled with water containing a pinch of salt, or a few drops of acid; this is placed in a tumbler of sulphate of copper; and the seal is immersed in the copper solution, while the other end of the wire, with its attached metal, is within the other liquid.—While upon seals, I may

mention, that their electrotypes are easily backed up with lead. When fresh from the solution, let them be varnished with rosin, dissolved in ether, or otherwise; after which, there will be no difficulty in causing the adhesion of tin or of soft solder, when required. Under other circumstances, the best means of tinning is to wash the metal with a solution of chloride of zinc and sal-ammoniac. Mr. Lockey recommended stearine instead of rosin.

56. *Battery Apparatus.*—A valuable improvement was devised in Russia, by Professor Jacobi,* and in England by a Member of the Electrical Society, Mr. Mason.† It consists in using a decomposition cell, analogous to that already described. (§ 11.) The constant voltaic pair (§ 17.) of copper and zinc is used as the generating cell. To the end of the wire attached to the copper is fastened a *plate of copper:* to the end of the wire attached to the zinc is affixed *the mould.* The sheet of copper and the mould are placed face to face in the decomposition cell. This arrangement will be better understood from the annexed figure. A is a cell of Daniell's Battery; (§ 17, 50.) B the de-



composition cell, filled with the dilute acid solution of sulphate of copper; *c* the sheet of copper to furnish a supply; *m* the moulds to receive the deposite.

* Vide Jacobi's Galvano-Plastic.

† Vide Proceedings of the Electrical Society, April 1840, p. 203.

To charge this, pour in the several solutions: hang a piece of copper on the brass rod *c*; connect this rod with the copper of the generating cell by the wire *z*; and the other rod *m*, with the zinc, by the wire *x*; *then*, and not *till* then, (§ 51.) hang the moulds on the rod *m*.

57. *Solutions.*—The solution used in this decomposition cell or depositing trough greatly depends on the battery or power employed; with a cell of Daniell's Constant Battery, a solution of about 2 sulphate of copper by measure, and 1 acid water (1 acid + 9 water) is undoubtedly the best. When less power is employed, a little acid in addition is found to be advantageous.

Professor von Kobell, instead of mixing acid water with the saturated solution of sulphate of copper, adds solutions of Glauber's salt, or of potash alum, or of nitrate of potash; by which means he obtains deposits of very malleable copper. Glauber's salt appears to be the best; it renders the solution more conductible, and is not itself decomposed by such feeble currents, as are here in use; while its solution will take up as much sulphate of copper as common water does. Two of saturated solution of sulphate of copper, and one of sulphate of copper in solution of Glauber's salt, are stated to be good proportions.

To the ordinary solution of sulphate of copper, Messrs. Elkingtons add caustic potash or soda in small quantities, until the precipitate is no longer redissolved by the solution, and they thus obtain a solution for the precipitating trough which gives up a greater quantity of copper for a given battery action, and gives it up also in a less space of time.

58. By an action already illustrated, (§ 13.) the copper from the solution is transferred to the mould; and the copper sheet is dissolved, being converted with the sulphuric acid into sulphate of copper; thus keeping up the strength of the solution. The time is somewhat longer by this method: two days will produce a medal of very good substance, firm and *pliable*. In speaking,

however, of the *time* required for these experiments, it must be borne in mind that this depends much on the *temperature*. If the solutions are kept boiling, a medal may be made in a few hours. A single-cell apparatus can be readily treated thus ; contrivances may easily be devised for applying the heat from a furnace or a spirit lamp. In severe weather, the action of the battery almost ceases. During the severe winter of 1840-41, from November to March, my batteries were placed within a few yards of the fire.

51. The advantages derived from the introduction of a decomposition cell are not limited to the production of single copies. Two or more may be made without any further consumption of material in the battery. If, for instance, two cells be placed side by side, and the plate of copper (§ 56.) be placed in one, and the mould (§ 56.) in the other: then, if the two cells be connected by means of a bent *copper wire*, dipping into the liquid of each, a circuit will be completed for the passage of the voltaic current. In *one* cell, the copper plate will be dissolved as before ; (§ 58.) and copper will be deposited on one end of the bent wire : in the *other* cell, the end of that wire will be dissolved, and copper will be deposited on the mould. If the bent wire is removed, and a *mould* is fixed (§ 31.) on one end of it to receive the copper released in the *first* cell, and a plate of copper* on the other end to furnish a supply in the *second* cell, the *one* action of the battery will produce *two* medals.

60. This mode of proceeding is not confined to taking merely *two* copies at a time ; it may be extended much further by using more cells. Experience has taught me that *six* is a very convenient number. The cells are to be connected, each to each, by bent wires, having a mould on one end and a piece of *copper* on the

* Soldering is not necessary for this purpose ; let a hole be punched in the copper, and the wire be passed through and twisted. It is then as well to varnish the wire (§ 31.) to protect it. Wires may be united by binding screws, cleft sticks, or twisting.

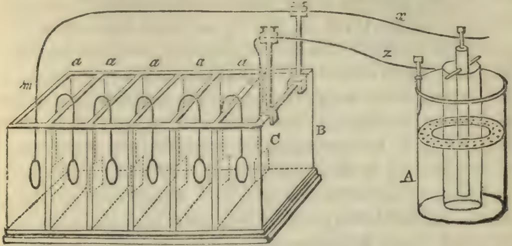
other. In proportion to the number of cells used, the *strength* of the solution (§ 57.) in them must be reduced by adding water, and its *conductibility* increased by adding acid. It is desirable to place the moulds and the sheets of copper as near together as possible, taking care that they do not *touch*. A single pair of copper and zinc in the battery or generating cell (§ 56.) will thus produce a series of *six* medals in three days, if the temperature is not much below sixty.

61. They who possess the earthenware troughs belonging to the Wollaston battery will find the cells, on account of their shape, very convenient for this purpose. These troughs commonly contain twelve cells: I have been in the habit of connecting six with one battery, and six with another; and producing, by the use of one trough, two dozen electrotype medals per week. The *shape* of these cells permits the moulds and copper plates to be placed face to face, which, with other precautions, insures an *even* deposite;—and near to each other, which shortens the length of liquid to be passed through, and thus facilitates the operation. The metal obtained by thus placing the moulds in series is of the best description. Troughs, for this purpose, may be made in well-varnished wood, of various sizes, and be divided into cells, by means of plate glass or glazed porcelain partitions.

62. The advantage of this mode, in point of economy, will be manifest, when it is remembered that for every *ounce* of copper released from the solution in the generating cell, an *ounce* will be deposited on *each* mould (page 20); and about an *ounce* of zinc will be consumed in effecting this. Whether, therefore, one, (§ 56.) or six, (§ 60.) or even twenty moulds be placed in series, the *same quantity* of *zinc* will be required. Hence an ounce of zinc may be made to furnish electricity enough to produce, according to the will of the experimenter, one, or six, or more medals, *each* weighing an ounce.

63. *Battery Apparatus extended.*—Annexed is an

engraving of a Daniell's battery, thus connected with a series of six cells, in each of which is a mould. A, the battery; B, the trough; *z*, wire connecting



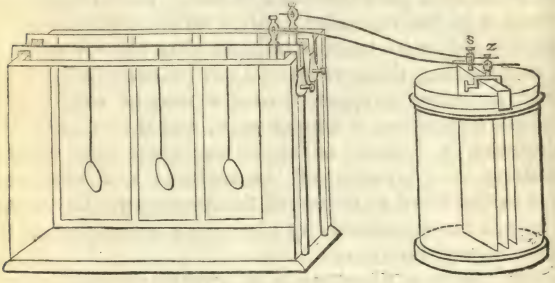
copper plate C with the copper (§ 4.) plate of the battery; *x*, wire connecting mould *m* with the zinc of battery; *a*, *a*, *a*, *a*, *a*, five bent wires, each having a mould at one end and a piece of copper at the other. (§ 31.) A little management is requisite in charging this, in order to preserve the bright surface (§ 51.) of the medals produced.—Charge the battery as elsewhere directed; connect the copper-plate C with the battery;—place a *wire* with its extreme ends dipping in the *extreme* cells of the trough; then, having previously connected the zinc and mould with the wire *x*, place the zinc in the porous cell and the mould in its place at *m;* in about two minutes, it will be covered with copper; after this, there is no fear of chemical (§ 60.) action; then remove the end of the copper wire from the cell containing *m*, and place it in the next cell;—complete the circuit with the bent wire *a*, having a mould at one end, and a sheet of copper at the other; after waiting a minute or two for a deposite of copper, remove the end of the wire one cell further forward; and so continue till the six moulds are placed in.

64. I have been in the habit of rendering the Electrotype art available in the production of the very apparatus which is destined to be employed in the art; and have produced a compact, neat, and very simple

battery, by the same process by which the battery thus formed will produce copies of medals. I take a large jelly-pot, and placing within it some wax, stand it by the fire, till the wax is melted, and the vessel thoroughly heated; then turn it about, so that the wax shall spread over every part of the interior: and having done this, pour away the superfluous wax. When cold, I rub plumbago, in the manner formerly described, (§38.) over the wax adhering to the *sides*. This vessel is then filled with a saturated acid solution of sulphate of copper, and in it is placed a porous tube; the tube is filled with acid water; a piece of amalgamated zinc is placed in the tube; the wire, attached to it, is bent over, and made to press upon the surface of the plumbago. In two or three hours, the whole of the interior where the plumbago is, will be covered with metallic copper. The vessel will now form one of the best and simplest generating or battery cells that can be constructed: this deposition of copper forms the copper-plate, (§ 3.) of the voltaic pair. The plaster diaphragm (§ 49.) and the solutions will complete the apparatus. Or the *whole* of the interior surface might be covered with plumbago; and when, after having been used for a week or two, the deposited copper should become thick enough, it might be drawn out, or the earthenware cell might be broken from it, and thus a complete cell of a Daniell's battery (§ 56.) might be obtained without a seam or join. To connect a wire with this coating, it is only necessary to brighten the end, and bend it so that it shall press closely.

65. *Smee's Battery.*—This very useful source of voltaic power was named by its inventor, the *Chemico-mechanical* Battery. It requires but one liquid for exciting it, namely, acid water; the metals are amalgamated zinc and platinized silver,—that is, silver on which molecules of platinum have been voltaically deposited in the form of a black powder.—A small quantity of the bichloride of platinum is mixed with acid water, and the solution is decomposed by the use

of a platinum terminal in connection with the *copper* of the battery, and the substance to be platinized in connection with the *zinc*. A few minutes' action will suffice. Platinum is sometimes platinized; but, for all practical purposes, silver is equally serviceable. This aggregation of small points facilitates the liberation of the evolved hydrogen, which escapes with a loud hissing noise, in place of adhering to the metal and interrupting the action. The arrangement is generally made with one platinized silver plate between two zinc plates, as in the following figure, where *s* is the silver plate connected with the copper of the usual decomposition cell, and *z* the zinc plate connected with the moulds. In employing this arrangement, care must be taken to avoid dropping any sulphate of copper into the acid water; for the copper would at once be reduced upon the silver plate, and by altering the nature of the battery would spoil it.



66. As the silver plate in this arrangement is between the zinc plates, it follows that the streams of hydrogen must *ascend* between the metals of the pair, so that, while in one sense they form a partial screen between the plates, they, on the other hand, prevent the plates being approximated within certain limits. A very ingenious modification of this arrangement has been devised by Professor Grove,* who substitutes platinized

* Vide Proceed. Elec. Soc. p. 117.—Sept. 21, 1841.

silver gauze in place of the *plate of silver;* as, by this means a facility is afforded to the hydrogen of passing through the apertures of the gauze, and making its escape at the *outer* side instead of *between* the two plates, the latter may be brought much closer together, without having the action intercepted by the presence of the liberated and escaping hydrogen.

67. *New Electrotype Battery.*—As it is no easy matter to obtain silver gauze, I advise the following substitute, which has its peculiar advantages :—Take a sheet of cleaned (§ 98.) copper gauze, of the *exact* size required, (for it must not be cut afterwards,) and affix to it permanently the binding screw or wire, which is to be employed afterwards in making connections. Place it then in a decomposition cell, containing sulphate of copper, and submit each side to the action of the battery, until a bright deposite of *pure copper* is thrown down, of sufficient thickness to coat all the wires, and to unite them permanently into one. Then remove and wash it in boiling water. After which, *electro-plate* it by the means to be described in Part II. A piece of *copper* gauze, thus prepared, will be even better fitted for the desired purpose, than if it were of *silver* wire; for the deposition of copper on it, and then plating this deposite, will have advanced one great step towards altering the character of the surface; and producing one better fitted to throw off the hydrogen. The operation will be completed, by platinizing according to the directions given above.

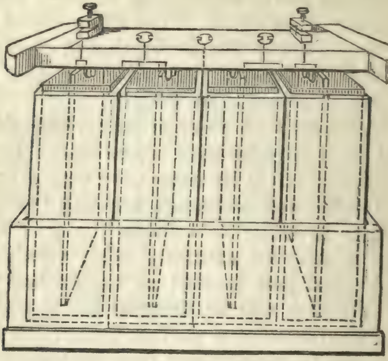
68. In the illustration of the platinized battery, (§ 65.) the metals are represented *parallel* and *perpendicular;* in the present arrangement there must be but one zinc plate, and the zinc and gauze must be *very near to each other*, but must *deviate* a few degrees *from the perpendicular;* and in such a direction that the platinized gauze shall be, as it were, *uppermost.* For, as the gas finds its way to the surface in perpendicular lines, such a disposition of the arrangement will at once admit it to pass through the interstices of

the gauze, and readily to escape by the desired channel, —the outside of the gauze. A better mode of constructing the apparatus is to employ a gauze on each side of the zinc. In this case, the zinc must be perpendicular; and the gauze not *exactly* parallel, but rather *closer* at the top than below. The difficulty of obtaining copper gauze led to the production of electro-lace, which was first suggested and made for this kind of battery by Mr. Phillips of St. Austell.

69. *Electro-Lace.*—A piece of lace is stretched on a frame, and well rubbed with warm wax: it is then held to the fire to effect its saturation with wax, and is placed afterwards, and while hot, between two pieces of blotting paper in order to remove the wax from the pattern; or it may be saturated with varnish. It is then plumbagoed and treated as an ordinary mould. A few hours' action will so deposite metal on it as to present the character of a perfect conversion into copper. This may be plated, and then platinized.

70. *Constant Acid Battery.*—Since the appearance of the *first edition* of this work, I have been employing, with slight modification, an ordinary *acid* battery, namely, a chemico-mechanical battery, in which roughened copper is used instead of platinized silver; and I find it admirably adapted to the purpose of Electrotype. Other circumstances being the same, it requires nearly *twice* the time of a sulphate battery: but this is in a degree compensated by the fineness of the deposite obtained, and the trifling expense attending its use.—The interior of a jar is coated with copper, (§ 67.) and the action is continued until the solution employed for this purpose is nearly exhausted. By this means, the surface of the copper obtained presents an infinite number of small points, which very readily part with the hydrogen. The principle is precisely that developed by Mr. Smee, and brought to practice in his platinized battery.—This arrangement may be adopted without the use of diaphragms. Amalgamated zinc is employed. I find that this kind of battery, variously

arranged, is greatly used in the arts. Sometimes a single battery is sufficient; at other times, a series of two, three, or four, having the zinc of one connected with the copper of the next; as in this engraving.—



I have myself been of late operating with this battery on a large scale, using surfaces of from 10 to 14 square feet:—if the copper surface has been exposed to the air for any time, while the battery is out of use, it should be well washed with acid water, or the old solution of zinc, before using it again, in order to remove any oxide of copper that may be there. Under these circumstances, I have every reason to be satisfied with its action, and to prefer it, from its simplicity and steady action, to any other form.

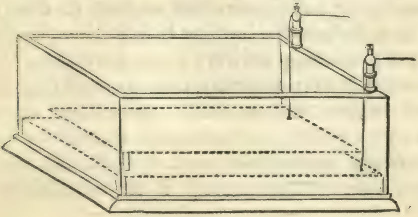
71. *Prince Bagration's Battery.*—A pan is filled with earth, which is then saturated with a solution of sal-ammoniac: a copper plate, having been first wetted with solution of sal-ammoniac, and then exposed to the air until a green film is formed, is thrust into the pan of earth; and opposite to it is thrust a zinc plate. Prof. Jacobi speaks favourably of this source of a constant power for the reduction of metals.

72. *The Earth a Battery.*—When slow actions are required, the moisture of the earth itself may be made

a source of power; all that is necessary being to bury in it large plates of zinc and copper. The native moisture of the soil constitutes the exciting liquid.

73. *Decomposition Cells* may be constructed of all sizes, according to circumstances, of wood, protected with varnish, or other compounds impervious to water. Two parallel wires are secured along the top; one is to be connected with the zinc, and the other with the copper of the battery. On the former are hung the moulds, by merely bending the wires attached to them, into a hook; and on the latter is hung a sheet of copper. These wires may be placed nearer to each other, as circumstances require. By this means, several medals may be made at the same time. This arrangement is most commonly adopted: it does not of course economise the zinc, as described in a former place. (§ 62.) One ounce of zinc produces six or more medals, not weighing *each*, but *all together* an ounce.

74. The deposited metal will present various thicknesses, according to the relative position of the mould and the plate of copper; if they are face to face, and parallel, the thickness will be uniform or nearly so; generally speaking, the copper on the lower part of the mould is thicker than that on the higher: this occurs from the specific gravity of the sulphuric acid, used to render the liquid conductible, determining it in a measure toward the bottom of the cell, rendering the lower part of the liquid more conductible than the upper. To cause a more uniform distribution, it is better to stir the liquid occasionally. But in many cases it is advisable to have a flat trough, as in the annexed sketch,



and to place the mould below and the copper plate above. With large casts, and those in deep relief, this is absolutely necessary; for without it a uniform thickness in the deposite is next to impossible, and the solution within the recesses of the mould, being unable to ascend and interchange itself with the rest, as it becomes exhausted of metal, soon gives a brittle deposite, and finally no deposite at all. My largest trough, which will contain upwards of a hundred gallons of solution, is of this form, and is lined with a mixture of asphalte and rosin. Mechanical arrangements keep the mould sunk, until the deposited metal is itself heavy enough for the purpose. The copper plate is removed once or twice a day and washed, to prevent defiling the cast with the impurities of the metal.

In order to hasten the thickening of the deposite, Professor Jacobi has recommended that copper filings be occasionally sifted upon the Electrotype; and when one batch of filings have become incorporated with the solid metal, by means of the reduced copper, he advises other siftings to be made: and so on.

75. *Management of the Moulds.*—Thus much, then, with respect to the construction of moulds, and the nature and various forms of the voltaic apparatus. From what has been said, the reader will be able to make his own selection, according to circumstances; he will see the capabilities of the several processes, and adopt the one best suited to his particular purpose. It remains now to give a few special directions in reference to the management of moulds, and of the voltaic apparatus generally. The copper solution will act *chemically* on the fusible metal, if the mould is placed in it before the battery is in action, and will produce on its surface a dirty, dark deposite. To guard against this, it is necessary that everything should be arranged before the mould is placed in the situation allotted to it. (§ 51.) The circuit should be completed by immersing the mould *last*. With this precaution, the immersion of the mould, if of metal, will be fol-

lowed by an *instant* deposite of copper on its *whole* surface; after which there is no fear of the oxide. A circumstance no less strange than true in these experiments, is, that the surface of a fusible mould thus managed is never *wetted* by the liquid in which it is placed; in fact, it never comes into *actual contact* with the liquid; its immersion in the liquid and its receiving a coating of copper are *simultaneous;* the one is the *instantaneous* cause of the other. When the copy is removed, the mould is as *bright* and as *dry* as when first made.

76. The deposition of the copper on the plumbagoed surface (§ 39.) of the wax moulds, is not thus *instantaneous.* The film of conducting substance with which they are coated being very thin, and not continuous, the operation is a step by step process from particle to particle. The deposition of copper is *gradual:* it commences in the neighbourhood of the wire attached to them, and spreads gradually over the remaining portion. These moulds *do* become *wetted,* and the medals obtained from them often come off with dirty surfaces; the medals also bring with them the whole or part of the plumbago, and hence the moulds, if not damaged, require a fresh coat of this, before they are used again. These dirty specimens may be very readily cleaned, if required; the mode will be described in the sequel. The production of dirty medals is the least evil arising from the use of plumbagoed moulds; there is one of far greater importance—one which requires some attention to escape. As the deposition of copper, which is *gradually* diffused over the whole surface, *commences* at one point contiguous to the connecting wire, it follows that the power of the battery at the first is concentrated in a *small* space. The consequence of this will be, that, unless means be taken to avert it, hydrogen will be evolved with the copper *at first,* decreasing in quantity till enough of the mould is covered with a film of copper to increase the size of the surface to

the requisite standard for releasing *copper alone*: after this all things go on well; but it is invariably found that the portion near the wire, from the irregularity of the primitive deposite, is *rotten* or very brittle. To prevent this, I always *begin* by placing a *wire* in lieu of a *plate*, opposite the plumbagoed mould, in the decomposition cell; this reduces the power of the battery or the quantity of electricity passing:—as the copper deposites, I immerse the wire to a greater depth, and when the mould is partially covered with copper, I remove the *wire*, place in the copper *plate*, and leave the experiment with the assurance of a successful result. But moulds furnished with guiding wires (§ 39.) may be put into the decomposition cell without the precaution of using a *wire* first, instead of a *plate*, as above suggested.—It will occasionally occur in wax moulds and sometimes in fusible metal moulds of very elaborately executed medals, that bubbles of air remain in some of the complicated interstices; these must be removed, or the result will be infallibly disfigured. They are removed by lightly brushing the surface of the mould with a feather, *immediately* after it is immersed in the liquid. If it should seem that any part of the mould is not sufficiently coated with plumbago, it may be removed from the solution, washed with water, dried with blotting-paper, and again rubbed with plumbago. This will sometimes save it, although generally such a condition of things announces a failure.

77. *Management of the Battery Apparatus.*—The Electro-typist, who expects to find *all* his experiments going on favourably, will be often grievously disappointed: with the best intentions and the most careful arrangements he may *sometimes* fail. For, after having observed *all* the directions hitherto given, his battery may have *too little* work to do, or *too much;* and this can only be determined by experience, and by attention to the principles laid down in this book. The former will produce the *dark powder*, elsewhere

mentioned (§ 76.); the latter a hard, *red*, *brittle* deposite, or a heap of crystals. The terms *too much* and *too little* are here used in a very general sense, and will be better understood by describing the *causes*, the *results*, and the *mode of rectifying* these irregularities.

78. If the battery is *too large*, or the copper plate in the decomposition cell is *too large*; or if the mould is *too small*, *hydrogen* as well as copper will be released, and the deposite will be the *dark powder*: the same will occur if the solution in the decomposition cell contains too *much* acid or too *little* sulphate of copper. To rectify this, the battery may be made *smaller* by pouring out some of the solution, and so exciting less of its surface; or a smaller copper plate may be used in the decomposition cell; or crystals of sulphate of copper may be thrown into the liquid contained therein; or the copper plate and mould may be removed *far* apart; or a *fine* wire may be interposed between the mould and the wire connecting it with the battery. Each or all of these alterations may be made according as circumstances or convenience shall dictate; a few days' experience will be better than pages of instruction.

79. If the battery is *too small*, or the copper plate in the decomposition cell *too small*; or if the mould is too *large*, or if the decomposition cell contains too *little* acid or too *much* sulphate of copper, or if the weather be too *cold*, the copper will be deposited *very* slowly, and will present a dull red exterior, and be of a very brittle texture; or will be thrown down in a crystalline form. The alterations necessary to rectify this defect will readily suggest themselves.

80. The medium between these two conditions fortunately has a very wide range, so that the chances of avoiding the two extremes are greatly in favour of the experimenter. The lines of demarcation within which the proper deposite is obtained, are, as may be imagined, not precisely defined. And hence the deposited metal possesses various gradations of character,

according to the circumstances under which it is obtained. When all things are going on well, if the mould be lifted out* of the solution, it will present a *brilliant, light, copper-coloured* surface; this characteristic can scarcely be mistaken after it is once seen.

81. In addition to this, the following general observations on the theory of the deposites, may be acceptable:—"It was thought that the rotten deposite —a characteristic with which all those who are but just initiated into the art are familiar—results from the presence of the sulphate of zinc among the sulphate of copper. . . . The real cause depends on the relation subsisting between the generating power, dependent on the action between the zinc and the acid, and the strength of the solution of the sulphate of copper, on which this power is exercised. If the latter is well saturated, the copper will be released pure and firm; if it is almost exhausted, the hydrogen gas will be released with the copper, and the deposite will be a dull *powder*. In the wide range between these two states is found the brittle deposite: it appears under many varieties of forms, according as the solution is nearer to a state of saturation or to one of exhaustion on the one hand; or according to the energy or weakness of the affinity between the zinc and its exciting solution on the other. This latter condition exists in a modified form, when a *large* piece of zinc is used with a *small* object to be copied. The deposite is very *hard*, but not tenacious. It may be easily broken. In copying seals, and such like small objects, little pieces of zinc an inch square are quite large enough."

82. The medals are removed from the *fusible* moulds by gradually raising the edges with a pointed instrument, a brad-awl, for instance, and then using it lever-fashion to raise the medal out of the mould. Care must be exercised in this, for the contact between the two is so close that the force occasionally required may cut

* The mould may be removed with impunity, after it is well coated with metal.

the medallion. The separation from the *wax-moulds* requires no force, they are laid face downwards on a table, and after pressing the slight over-lapping edge of copper with the brad-awl, in different parts of the circumference, the two may be pulled apart.

IV.—Bronzing.

83. If proper precautions are taken, the medals from the fusible moulds will *generally* present a bright *copper* surface; occasionally, however, they will present a very *brilliant* surface, greatly resembling *silver*. When this is the case they may be placed, without further trouble, for the cabinet. The silvery tint is only obtained on *first* specimens: it would seem that the surface of the *new-made* mould is covered with a metallic film, which attaches itself *firmly* to the surface of the deposited copper. It is so firmly attached, that it may be polished with a leather, or plate-brush, without sensibly affecting it. If specimens of this description are exposed to the air, they will occasionally require the application of the plate-brush to restore their primitive brilliancy.

84. *Chemical Bronze.*—There are many modes of bronzing employed in the arts, the intent of each is to bring out the workmanship of the object. The selection is entirely a matter of taste. To prevent too great a sameness of appearance in a cabinet, it is perhaps better not to confine oneself to a solitary method. —A *chemical* bronze may be made by boiling two ounces of carbonate of ammonia with one ounce of acetate of copper in half a pint of vinegar, till the vinegar is nearly evaporated. Into this, pour a solution consisting of sixty-two grains of muriate of ammonia, and fifteen grains and a half of oxalic acid, in half a pint of vinegar. Replace the vessel on the fire till the contents boil; when cold, strain through filtering paper; preserve the liquor for use. The remaining sediment may be again treated with another half pint of the

solution. This preparation must only be applied to medals perfectly *bright* and *clean.*

85. Dirty specimens may be polished by an article used in domestic economy, consisting of rottenstone, soft soap, and water; the medal is to be well rubbed with a hard brush dipped in this. Care must be taken not to scratch the medal. It must afterwards be washed in water and placed to dry; when dry, the application of the leather and plate-brush will produce the required polish. Medals may also be cleaned by dipping them for a few seconds in nitric acid, either concentrated or diluted; wax and grease may be removed by boiling in pearl-ash and water, or by pouring the boiling ley on the medals; or by washing with turpentine. Cleansing processes will be more fully described in the Second Part, when we come to electro-gilding and plating, in which they are of prime importance.

86. In applying the bronze, first warm the medal, then dip a camel's hair pencil into the liquor, (§ 84.) and brush the surface for *half a minute; immediately* after, pour *boiling* water over it; *directly* the medal is *dry*, rub its surface lightly with soft cotton, *very* slightly moistened in linseed oil: gentle friction with a piece of dry cotton will finish the operation. The colour produced by this means, is red; its tint varies according to circumstances. Medals bronzed thus must be examined occasionally before they are consigned to the cabinet; for if perchance the vinegar has not been *perfectly* washed away, they will be disfigured by the formation of a green powder,—the acetate of copper. Should this occur, it may be removed by means of the moist and dry cotton.

87. *Black Lead Bronze.*—A very beautiful bronze is obtained by the simple application of plumbago; it is obtained in a few minutes, and with very little trouble. The tint obtained seems very much to depend on the condition of the *surface* of the *original medal;* copies of some medals 'take' the black lead better than those

of others. To produce the tint in the greatest perfection, the operation should be performed *immediately* after the medal is separated from the mould. *Bright* specimens from *fusible* moulds are best, but all others may be thus treated; those taken from wax should be cleaned with pearl-ash or soda.

88. The bronze is obtained by brushing the surface of the medal with plumbago; then placing it on a clear fire till it is made too hot to be touched, and applying a plate-brush, as soon as it ceases to be hot enough to burn the brush. A few strokes of the brush will produce a dark brown polish, approaching black, but entirely distinct from the well-known appearance of black lead. If the same operation is performed on a medal that has been kept some days, or upon one that has been polished, (§ 85.) a different but very brilliant tint is produced. The colour is between red and brown. The richness of colour thus produced, is by many preferred to the true dark brown.

89. *Carbonate of Iron Bronze.*—Very beautiful tints are produced by using the substance commonly known as plate-powder, or rouge; after moistening it with water it is applied and treated precisely in the same manner as the plumbago. Some care and practice are required in its use, lest it should *stain* instead of *bronze* the medal.—I have received from the publishers of this book a specimen of bronze superior to any I have elsewhere met with. It leaves nothing to be desired. —Should an experiment fail, the several bronzes may, in many cases, be removed, and the attempt can be repeated.

90. *Mounting the Medals.* — I have adopted a method of mounting the medals obtained from the *fusible* moulds, (§ 20.) which gives a finish to their appearance. I obtain pale green cards, the size of visiting cards; and cut some of these into single squares; *the width* of the card being the side of the square; others into smaller squares, *half the length* of the card forming the side of the square. A pencil

circle is drawn the size of the medal; and two *ink* circles in order to 'throw' the medal 'forward.' The part within the pencil circle is cut out; and waste cards are cut to fit the extra edge of the medal. The two cards being fixed together with very strong gum water, the medal is placed in, and secured by another card gummed on at the back. The obverse and reverse are then gummed back to back, and thus the appearance of a perfect and solid medal is produced, equal, in point of workmanship and beauty, to the original. To hold the cards together until the gum dries, I use cleft-sticks. The medals obtained from wax moulds, having no addition to the edges, are not well fitted to be mounted thus: they may simply have any roughness removed from their edges with a sharp file, and be placed in the cabinet without being fitted with cards.

V.—Concluding Observations.

91. Having now gone systematically through the process of working in copper, by means of the voltaic current, halting here and stepping aside there, in order to make all things as clear as possible; and having fulfilled my promise (§ 1.) of leading the reader "from the original medal to the perfect copy, ready for the cabinet;" I trust he is in a condition, so far as these instructions are concerned, to go from small things to great, and by increasing the size of his apparatus, as it shall seem good to him, to carry out on the large scale what he has here been taught to do on the small. I now, therefore, refer him to Part II., in which the manipulation with gold and silver, and other metals and alloys of metals, will be detailed; and all and sundry the leading applications and the extensive ramifications of the art will be set before him.

END OF PART I.

INDEX.

London: Printed by Stewart and Murray, Old Bailey.

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Height.	
2 by 3½	6d. each.
4 by 4½	10d. ,,
3½ by 5½	1s. ,,
3½ by 6¾	1s. 3d. ,,
2½ by 4¾	10d.
7 by 7	1s. 6d. ,
4 by 4 ⅞ wide	1s. ,,

Brushes for Plumbago . . . . each 1s.
Ditto Bronzing . . . . 1s. 6d.

KNIGHT'S IMPROVED CLICHEE MOULDS.

These moulds are so perfect that they produce Electrotypes quite equal in beauty and perfection to the original medals.

THEY CONSIST OF

A Grand Series of English Medals, published by JAMES MUDIE, Esq., commemorating the success and valour of the British arms in the Peninsula.

Descriptive Catalogue of the entire series, consisting of Forty Medals, price 6d.

ALSO,

The Grand Series of Medals, struck at the National Mint of Paris, By order of NAPOLEON BONAPARTE, Commemorating the most remarkable battles and events during his dynasty.

Descriptive Catalogue of the entire series, consisting of 141 Medals, Price 1s.

Cost of the Clichee Moulds.

		s.	d.	
$1\frac{3}{8}$ in. diameter, and under	. . . .	1	3	each.
$1\frac{3}{4}$ " " "	. . . .	1	6	"
2 " " "	. . . .	2	6	"
$2\frac{1}{2}$ " " "	. . . .	3	0	"
3 " " "	. . . .	4	0	"
$3\frac{1}{2}$ " " "	. . . .	5	0	"

The Mudie series 1*s*. 6*d*. each; or the set, consisting of 70 moulds, £5; several of the Obverses being duplicate.

The Napoleon series—the cost according to diameter, as per above List for the separate moulds; and the complete set, consisting of 212 moulds, several of the Obverses being also duplicate, £16.

Very superior Black Lead (Plumbago) . . .	per box,	1s.
Sulphate Copper	per lb.	6d.
Muriate Ammonia	"	1s.
White or Virgin Wax	"	3s.
Stearine		1s. 10d.
Metal for Clichee Moulds		3s. 6d.
Cyanide Potassium	oz.	9d.
Gold :—		
Wire and plate	dwt.	5s. 6d.
Prepared Oxide, in bottles, each		7s. 6d.
Solution, ready for use, in 3 oz. bottles, each . .		3s.
Silver :—		
Wire or plate	per oz.	8s.
Prepared Oxide, in bottles, each	3s. 6d.,	6s. 6d.
Solution, ready for use, in 3 oz. bottles		1s. 9d.
Solution of Phosphorus in Sulphuret of Carbon,	per oz.	1s.
Platinized Silver for Smee's Batteries	"	10s.
Gutta Percha prepared expressly for taking moulds from Plaster Casts		

KNIGHT'S NEW PREPARATION FOR BRONZING ELECTROTYPE MEDALS.

This, being applied in the form of a Powder, instead of a Liquid, as is usually the case, does not injure or clog in the slightest degree the sharpness of the finest line.

Sold in Bottles, with Directions for use, Price 2s. each.